Chapter

Radial Artery Access

Carmelo Panetta and Johnny Chahine

Abstract

Radial artery access for angiography has matured over the past two decades and is now the preferred point of access for most patients. Lower bleeding rates in clinical randomized trials have translated into lower mortality prompting change in the guidelines. Advances in technique with use of ultrasound for access to properly size the sheath, proper dosing of anticoagulation and new techniques for sheath removal have dramatically lowered radial artery occlusion rates. Radial artery spasm has improved with vasodilators and proper sedation. Advances in support boards and sheath extension have opened up left radial access. Advances in lower profile sheaths and sheathless systems allow larger catheters in smaller arteries. Advances in longer balloons and sheaths have opened up radial access for peripheral interventions. Areas of clinical research include use of ulnar artery compared to radial, left versus right radial access, use of radial artery for a surgical conduit after angiography, radiation exposure and advantage of radial approach in the elderly.

Keywords: radial artery, ulnar artery, radial artery occlusion, sheathless guide, left radial support

1. Introduction

Radial artery access for angiography was first described in 1948 via cut down and direct insertion into either right or left radial artery [1], and in 1989 direct coronary angiography with percutaneous access via left radial artery [2]. Since then, radial artery access has advanced catheterization for patients by reducing vascular site bleeding which translated into both lower mortality and lower costs [3, 4]. Lesser known advantages include opening up both femoral arteries for larger sheaths for both hemodynamic support, complex coronary, peripheral or structural cases, as well as patient satisfaction. Acceptance has been slow by operators given the artery is smaller, orthopedic concerns of the operator with left radial and navigating catheters thru tortuous vascular anatomy, resulting in longer cases and higher radiation exposure [5, 6]. Advances in both techniques and medical devices have overcome many of the concerns opening up the wrist arteries for a far greater number than the past, translating into benefits for patients, hospitals and physicians.

2. Outline for the chapter

1. Bleeding reduction and impact on mortality

2. Ultrasound access

3. RAO: prevention/therapy

4. Radial Access Support

5. Thin walled sheaths and Sheathless guides

6. Peripheral interventions via radial approach

7. Areas of research: ulnar vs. radial; use of radial for graft; radiation exposure; elderly

3. Bleeding reduction and impact on mortality

Radial access found a niche initially by patient preference and potential benefit given the complications with femoral or brachial access [1]. Radial artery access for coronary angiography and percutaneous intervention is deemed safer than femoral access, positively impacting mortality, and bleeding risk.

A multicenter randomized controlled trial involving 8404 participants with acute coronary syndrome found that using radial access decreases major bleeding [RR 0.67 (0.49–0.92), p = 0.01] and all-cause mortality [RR 0.72 (0.53–0.99), p = 0.045] compared to femoral access [7]. The RIFLE-STECAS trial involved only patients with ST-elevation myocardial infarction (STEMI) (n = 1001), and found lower bleeding rates (7.8% vs. 12.2%, p = 0.026) and cardiac mortality in the radial access group (5.2% vs. 9.2%, p = 0.02), and decreased median length of stay [5 [4–7] days vs. 6 [5–8], p = 0.03] [8]. The RIVAL trial separately studied the outcomes of STEMI (n = 1958) and non-ST elevation acute coronary syndrome (n = 5063) patients. Survival benefit and decreased bleeding risk with radial access was seen in the STEMI group [9]. A comparative study of STEMI patients in cardiogenic shock after PCI (n = 2663) showed that 1-year mortality was lower using the transradial approach compared to transfemoral (44% vs. 64%, p = 0.004), with radial artery access being an independent predictor of 1-year mortality [HR 0.65 (0.42–0.98), p = 0.041] [10]. The rate of TIMI 3 flow was identical in both groups. Major bleeding was higher in the femoral group (25% vs. 13%, p = 0.04) as well as bleeding related to access site (9 vs. 0.9%, p = 0.01) [10]. The STEMI-RADIAL trial also involved STEMI patients (n = 707), and found decreased composite endpoint of death, myocardial infarction, stroke, major bleeding, and vascular complications (4.6% vs. 11%, p = 0.003) but similar mortality rates at 30 days (2.3% vs. 3.1%, p = 0.64) and 6 months (2.3% vs. 3.6%, p = 0.31) [11]. The SAFARI-STEMI trial enrolled 2292 out of 4800 patients, halted prematurely because of futility finding 30-day mortality was similar between the radial and femoral access groups (RR 1.15 (0.58–2.30), p = 0.69). There was no difference in bleeding risk [RR 0.71 (0.38–1.33), p = 0.28] [12]. These findings can be explained by the fact that the proceduralists were experienced cardiologists at high-volume centers, a closure device was used in 68% of patients in the femoral group, less 2b3a inhibitor was used and bivalirudin was favored in 92% of those patients, which is known to cause less bleeding than heparin. [12].

Yet the totality of data from 12 randomized clinical trials over the past decade found particularly in those with acute coronary syndrome, a lower bleeding rate translated into lower mortality [3]. This prompted a radial first approach by the American Heart Association for those with acute coronary syndrome [3].

4. Ultrasound access

Ultrasound (US) for radial access from several smaller studies implied a benefit in time to access [13, 14]. The RAUST trial included 698 patients and showed that an ultrasound-guided approach decreased the number of attempts (mean 1.65 ± 1.2 vs. 3.05 3.4, p < 0.0001) and the time to getting access (88 ± 78 seconds vs. 108 ± 112 seconds, p = 0.006) [15]. In another randomized controlled trial performed in Australia that enrolled 1388 patients, ultrasound use decreased time to getting access (93 vs. 11 seconds, p = 0.009), the number of attempts (1.47 vs. 1.9, p < 0.0001) with increased chances of success from the first try (73% vs. 59.7%, p < 0.0001) [16]. Besides the faster and higher success rate, pre-puncture ultrasound can prevent vascular complications by properly sizing the radial artery to sheath diameter [17].

5. RAO: prevention/therapy

Radial artery occlusion (RAO) is common and is seen in up to 10% of patients early after the procedure, although the more recent trials (after 2018) showed an RAO rate of less than 3.7% [18].

Multiple preventive techniques have been described including importance of anticoagulation, proper sizing of the radial artery to sheath/guide, patent hemostasis, prophylactic ulnar compression and shorten duration of compression [18]. A meta-analysis that included 31,345 patients and 66 studies concluded that high dose heparin (5000 IU) administration decreased the risk of RAO by 64%, and reducing compression times decreased this risk by 72% [19]. A recent study of high dose (100 IU/kg body weight) versus (50 IU/kg/body weight) lowered RAO [20]. That is why it has been recommended to administer at 5000 U or 50 or higher IU/kg body weight unfractionated heparin for all procedures with radial artery access [18, 21]. Importance of having sheath to radial artery diameter < 1.0 is considered best for reducing RAO [18, 21], pushing industry to provide sheaths with thinner walls or sheathless guide systems. The 6.5 F sheathless Eaucath appeared to have lower RAO compared to thin walled 6F sheath, 0.0% vs. 2.0%, p 0.031 with sample size of 600 randomized patients [22].. Although thinner, the RAP and BEAT (Radial Artery Patency and Bleeding, Efficacy, Adverse evenT) trial found thin walled 6French (F) sheath failed noninferiority to 5F sheath, (3.7% vs. 1.7%, pnon-inferiority = 0.150) [23]. Even a difference of 0.24 mm (5F standard with 2.22 mm vs. thin-walled 6F with 2.44 mm) may have lower RAO, implying smaller is better. Reduction of RAO rates have been reported after subcutaneous injection of nitroglycerin at the radial access site before the procedure (5% vs. 14%, P = 0.04) and the use of intraarterial nitroglycerin after the procedure (8% vs. 12%, p = 0.006) [24]. Maintaining radial artery patency during hemostasis is proven to reduce RAO rates, or patent hemostasis. [18, 21]. This can be achieved by periodically monitoring oximetry-plethysmography after the procedure to ensure radial flow [25] Pneumatic radial compression based on the patient's mean arterial pressure and concomitant ulnar compression to increase radial flow have also been shown to be beneficial [26].

6. Radial access support

Support for access in the wrist has advanced over the past decade, with a focus on left arm support, radiation protection and having a board to hold equipment.

There has been a surge in the last several years to use the left wrist to circumvent challenges with access to the left internal mammary artery post coronary artery bypass surgery (CABG), those older than 75 years, short statue less than 5 foot five inches (1.65meters), and long term hypertension [5, 27]. Wrist access requires support for: access in the artery, management of equipment, radiation exposure along with comfort of the patient and the operator. Right arm support has advanced with arm extension boards to help with access, for example Radial Runway (TZ Medical), Rad Rest (Merit) or STAR system (Adept Medical) to help with access of the artery, especially useful if not using ultrasound **(Figure 1)**. Right boards include the Cardiotrap (Radial Solutions) (**Figure 2a**), EGGNEST from EGG medical (**Figure 2b**), STARSYSTEM by Adept Medical, Rad Board from Merit provides both arm support and radiation protection. The left arm support for both access and arm support across the abdomen is the Left Arm Support System by LP Medical **(Figure 2c)** and Cardiotrap from Radial Solutions. Other options for arm support alone include STARSYSTEM by Adept Medical, Cobra Board by TZ medical (**Figure 2d**), left radial support sling by Academic Health Science Network and Tesslagra sterile sleeve by Tesslagra Design Solutions. Once access is made for the left wrist and arm is placed across the abdomen, use of sheath extension such as the StandTall by

(a) (b)

Figure 1.
Devices to hold the wrist out to assist in accessing the radial artery. a. Radial Runway©, TZ medical. b. Rad Board© and Rad Rest©, Merit Medical.

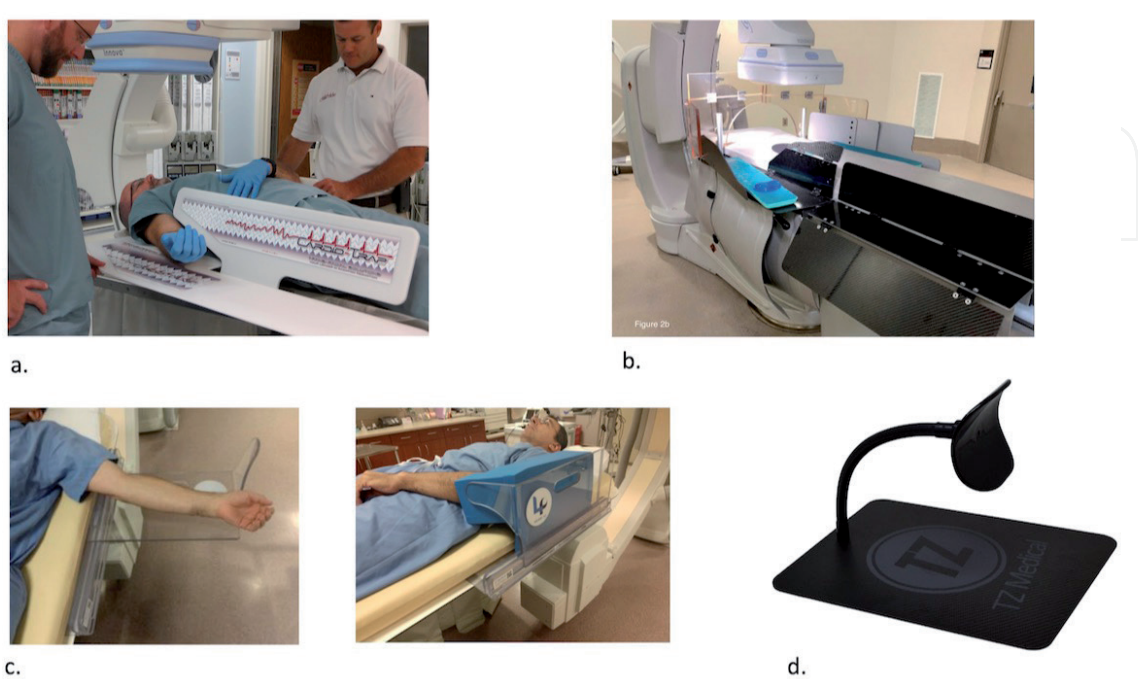


Figure 2.
Arm support systems. Right arm: a. Cardiotrap® (Transradial solutions, SC) b. EGG Nest® (EGG Medical, MN) c. Left arm support system (LASS) (LP Medical, MN) d. Cobra Board® (TZ Medical, OR).

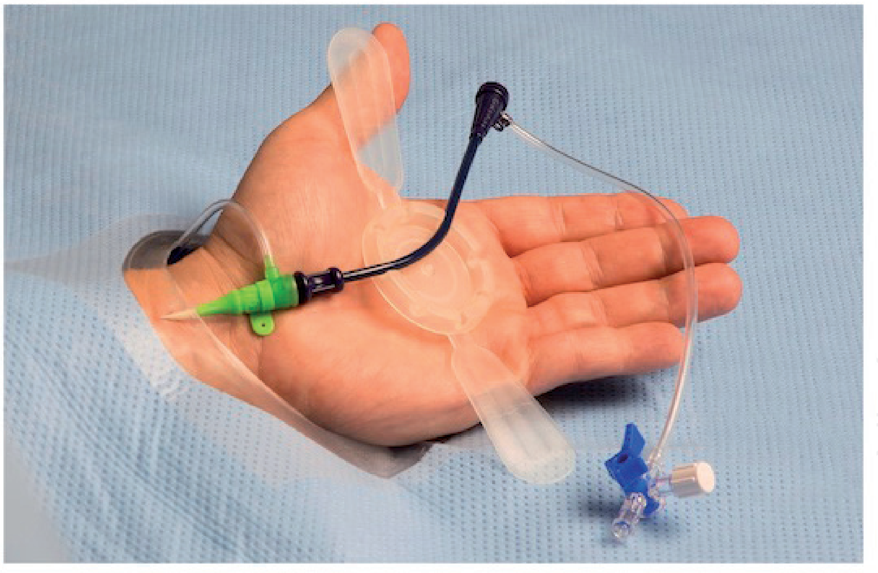


Figure 3.
Sheath Extension Standtall® (Radux Devices, MN).

Radux (**Figure 3**), distal radial approach or having a long sheath partly extended out (although risk for kinking of the sheath) will allow the physician to have an upright position on the right side of the patient while manipulating the catheter or guide.

7. Thin walled sheaths and Sheathless guides

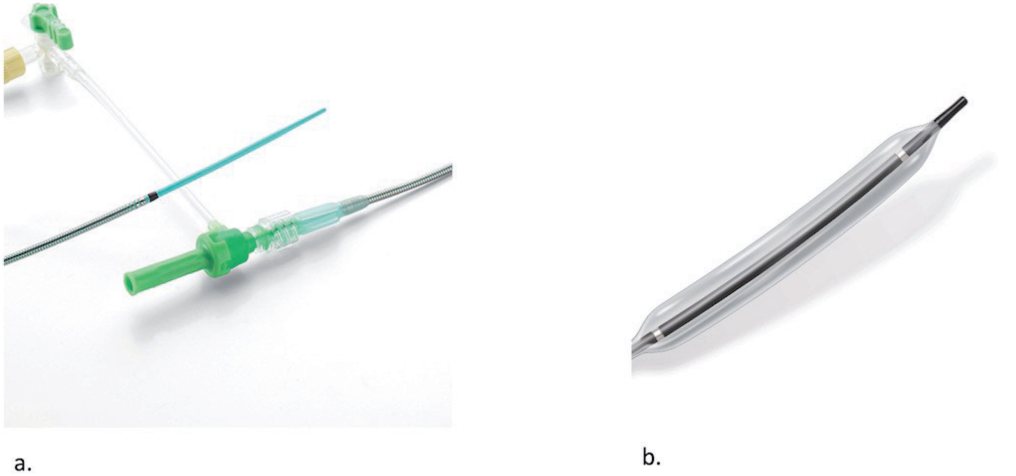
Small diameter of the radial or ulnar artery has been overcome with thinner sheaths. For example the Slender (Terumo) (**Figure 4**) 6F outer diameter is 2.46 mm versus 2.62 mm for standard sheath outer diameter and the Slender 7F drops the outer diameter from 2.95 down to 2.79 mm. The downside is kinking of the thinner walled sheaths especially if partly inserted into the artery.

Figure 4.
Thin walled sheath, GLIDESHEATH SLENDER® Introducer Sheath – ©2020 Terumo Medical Corporation. All rights reserved.

Sheathless guides (Eaucath system from Asahi Intecc Co Ltd. or Railway system from Cordis) have opened up radial access for smaller arteries. The OD of the 6.5Fr SheathLess Eaucath is 2.16 mm, similar to the OD of the 4Fr sheath at 2.00 mm. The OD of the 7.5Fr SheathLess Eaucath is 2.49 mm, similar to the OD of the 5Fr sheath at 2.29 mm. The passing of the sheathless guide requires special attention to withdrawing the dilator before entry into the aorta from the subclavian. One other option is the use of an inflated balloon in the tip of the guide prior to passing into the artery referred to balloon-assisted shealthless transradial intervention (BASTI) [28]. The challenge is the use of 0.014 wire for support versus 0.021 or 0.035 and, as with sheathless guides one other issue is over manipulation of the guide without a sheath could induce spasm.

8. Peripheral interventions via radial approach

Peripheral interventions have adopted radial access to lower bleeding or due to hostile femoral artery anatomy [29]. Peripheral interventions include aorta, visceral, iliac/femoral and, rarely, popliteal [29, 30]. The learning curve for radial approach for peripheral interventions [29] may account for an increase in radiation [31]. Distance from the wrist to the site of percutaneous intervention is a limitation. Longer sheaths such as destination sheath by Terumo (**Figure 5a**) have allowed improved positioning for equipment. As with the sheathless guide, careful attention should be placed on pulling back the dilator before entering the aorta. Longer catheters have been developed by Terumo under the radial to peripheral program, (R2P) with shafts upto 200 cm including both balloons and self expanding peripheral stents (**Figure 5b).** Other companies have 170 cm catheter lengths including: Ultraverse RX (Bard); the Advance 14LP low Profile balloon (Cook); and the Armada 14 (Abbott), Mini Ghost (B.Braun), Steriling SL Monorail (Boston Scientific), Sleep OTW (Cordis) and Amphirion Deep OTW (Medtronic) all with catheters upto 150 cm in length. The longer shafts have furthered the use of radial access, along with left arm support and sheath extension but limited length of catheters with covered stents or drug coated balloons for infrainguinal disease [32].



a. b.

Figure 5.
Long sheath R2PTM DESTINATION SLENDERTM Guiding Sheath b. 200 cm Long shaft R2PTM METACROSS® RX PTA Balloon Dilatation Catheter - ©2020 Terumo Medical Corporation. All rights reserved.

9. Areas of research

With an increase in clinical studies showing the advantages of radial access also came insight into complications including radial loops, high take off of radial artery, spasm, dissection [5]. The ulnar artery became another option, initially avoided due to location, as the ulnar artery is often deeper beneath the skin and concern for ulnar nerve damage or hand ischemia but reports for both coronary and peripheral angiography and interventions rasie doubts regarding those concerns [33–35]. A meta analysis of five trials found similar complications between radial vs. ulnar approach [36]., crossover was higher with ulnar versus radial approach but this was driven by one trial [37]. This trial was to enroll 2286 patients but was stopped early with 902 enrolled after finding cross over to another site was 26% more likely with ulnar approach compared to radial, with the caveat that ultrasound was not used for access. Further studies are warranted in comparing radial versus ulnar using ultrasound.

Radial artery is being reinvestigated as a favored coronary artery bypass graft (CABG) over veins with recent meta analysis of 1036 patients having lower mortality with arterial grafts over venous grafts [38]. This has prompted the ROMA prospective randomized trial comparing vein to arterial grafts for CABG. One study from 2003 found radial grafts that were previously cannulated had a lower patency rate [39]. Several other studies have found changes in the radial artery including arterial tears, radial intimal hyperplasia and loss of reactivity after sheath insertion [40–42]. This has prompted some surgeons to request interventional cardiologists not to use nondominant radial artery for angiography. Further studies investigating radial or ulnar access prior to CABG are recommended.

Radiation exposure is a constant worry in the catheterization laboratory [43]. Advances in technology have lowered radiation exposure including improved shielding. Clinical data have shown radial, particularly right radial, to have more radiation exposure compared to femoral approach [6]. Comparison of left radial to femoral approach in one randomized trial [44] found higher radiation compared in radial approach, although this was done prior to newer technology to assist in left radial such as sheath extension (eg. Stand Tall, Radux Devices) and left arm support systems. Multiple randomized trials found less radiation with left versus right radial [45–49] although one trial found more radiation with left radial [50]. Avoiding steep angles, particularly LAO -Caudal, lower magnification, lower frame rate with fluoroscopy, and distance is recommended [51, 52]. Further research comparing access sites is warranted to better understand with current technology the risks of radiation exposure.

Elderly have higher risk for CV procedures [53, 54] and benefits of radial approach for reduction in bleeding complications is a valid concern. Age appears to be a predictor of failure or cross over to another site [5, 19]. Yet studies in the elderly including a retrospective analysis have not shown increased time to treat ST elevation myocardial infarction [55]. A review of patients enrolled in randomized Rival trial found less complications but higher cross over rates in the elderly [56]. Further studies are warranted in those 75 years and older to compare radial (left versus right) and femoral access points in examining cross over rates, radiation, bleeding and success.

Radial access has dramatically changed over the past twenty years with advances in both technology and technique to bring this approach to the forefront in both the acute setting as well as for complex procedures.

Conflict of interest

Carmelo Panetta is co-owner of LP Medical LLC. Johnny Chahine has no conflict of interest.

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